Characterization of Dehydrogenation in Martian Amphibole

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Abstract No. Dyar4774
Beamline(s): **X26A**

Introduction: The search for evidence of water on Mars has focused attention on a variety of hydrous minerals, such as jarosite and ferrihydrite, that are formed by surface processes. However, a significant proportion of the hydrogen budgets on Mars and other planets may be hosted by nominally anhydrous minerals such as olivine and pyroxene, as well as by phases that are stable over a wide range of pressure and temperature such as amphibole. Not only can the presence of water and the partitioning of that water between minerals have a profound effect on mechanical behavior of materials, but it can also provide a monitor of hydrogen and water fugacity and fractionation at the time of crystallization. Correct interpretation of the D/H, H (and Fe^{3+}) contents of these minerals is predicated on understanding of dehydrogenation processes and their kinetics.

The most commonly occurring hydrous phase in Martian meteorites is amphibole, which occurs in very small grains (<50 μm) as inclusions. Previous work has suggested an perfect inverse correlation between the Fe^{3+} and H contents of this mineral, as it is known to be vulnerable to dehydrogenation in terrestrial occurrences (Figure 1). Development of the capability to measure Fe^{3+} contents of these tiny grains therefore also gives us the potential to assess the H contents in these tiny grains, as a complement to H analyses by SIMS.

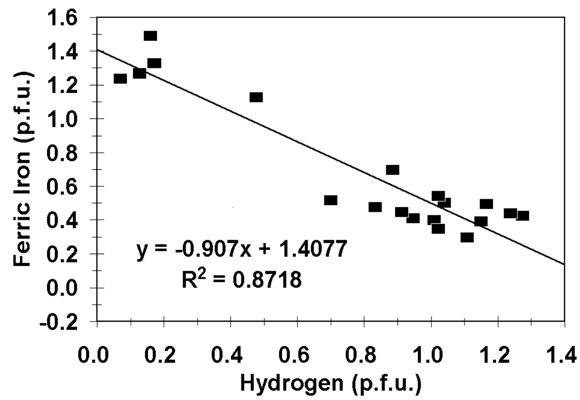

Figure 1. Relationship between hydrogen and Fe^{3+} contents of mantle (terrestrial) amphiboles. This correlation can be used to predict H contents from Fe^{3+} measured by the XANES micro probe.

Methods and Materials: In this study, we set out to accomplish two goals: 1) confirmation of a valid calibration line for use in analyzing amphiboles at the NSLS, and 2) measurement of Fe^{3+} contents of hydrous phases in thin sections of Martian meteorites. For the former task, we collected a suite of terrestrial amphiboles for which Fe^{3+} contents were measured by Mössbauer spectroscopy and ranged from 0-100%. These samples were analyzed using the X-ray micro probe at x26a using a beam diameter of <20 μm. For the latter objective, we obtained a thin section of Martian peridotite LEW 88516 from JSC.

Results: The calibration line that was determined using amphiboles of independently known Fe^{3+} content appears to be robust, as it has an R^2 value of 0.968 (Figure 2). XANES spectra were then collected on the kaersutitic amphibole in our thin section. The amphibole in LEW 88516 was then determined to have a composition of:

$Si_{5.246}Al_{2.77}Ti_{1.055}Cr_{0.022}Fe^{3+}{}_{0.666}Fe^{2+}{}_{1.269}Mn_{0.037}Mg_{1.589}Na_{0.366}Ca_{1.634}O_{11}(OH)_{0.817}$.

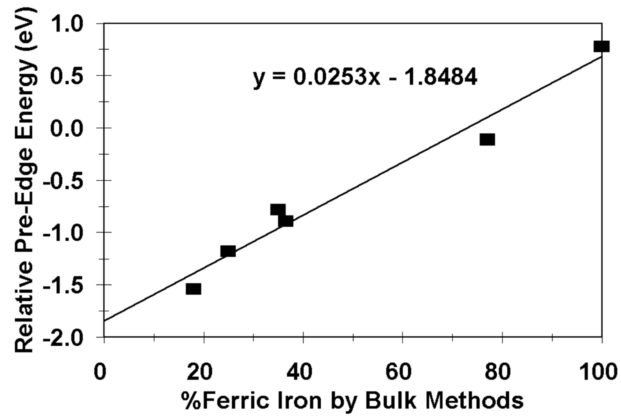

Figure 2. Calibration line for amphibole group minerals, based on XANES pre-edge positions in spectra of amphiboles for which Fe^{3+} contents were determined by either Mössbauer spectroscopy or wet chemistry.

Conclusions: If the inverse relationship between Fe^{3+} and H that is observed in terrestrial samples is also preserved in extraterrestrial samples, then relatively reduced source magmas might be expected on Mars. Further measurements by XANES and by SIMS should strengthen this conclusion.

Acknowledgments: This work was supported by NSF grants EAR-9806182 and EAR-9909587, and DOE-Geosciences DE-FG02-92ER14244.